



NSF Division of Astronomical Sciences (AST)

AAAC Report

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Jim Ulvestad

Division Director

@UlvestadNSF



High-Level Summary

- Outstanding science opportunities offered/developed
 - ALMA, EVLA, Dark Energy Camera, GPI, DKIST, LSST
 - AAG has been stable, with funding rate inching back above 20%
 - Interagency: NN-EXPLORE with NASA; telescopes/instruments with DOE
 - NSF requested ~\$87M for AST facility construction in FY 2017
 - Second round of MSIP awards made
- Partnerships with NASA and DOE have strengthened
- New collaborations with DoD (LBO) and NOAA (GONG)
- Potential impact of LIGO detection
- Mid-decadal review and Kavli Workshop reports released
- Unknown prospects for budget increases this decade
 - Next 1.5 yr are critical for divestment activities
- Continued progress at the science frontiers



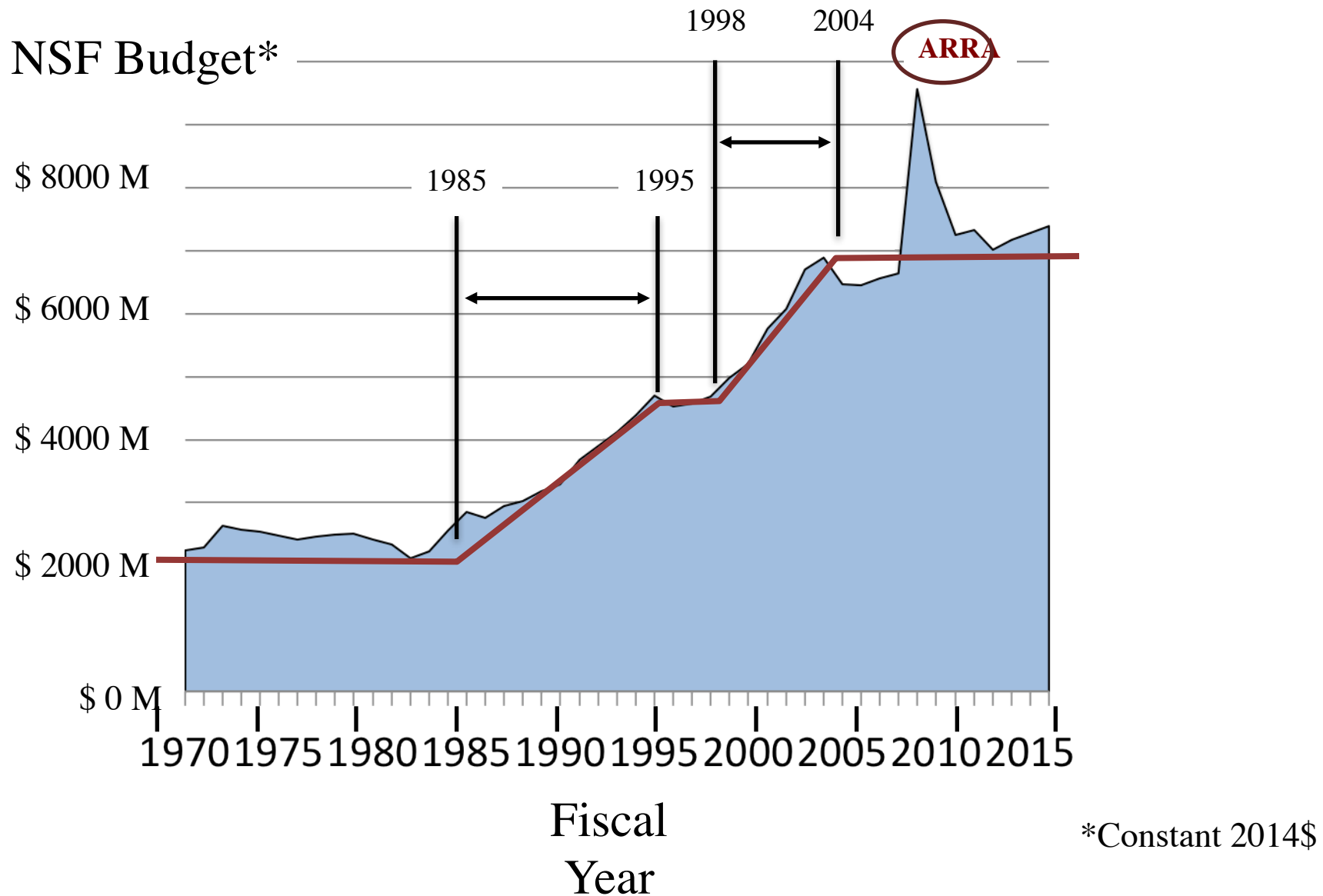
Outline

- AST Background
- Science and Facility Highlights
- Budget Outlook, Divestment, and Environmental Reviews
- Recent Community Reports
- Individual Investigator Programs



AST and NSF Background

NSF Funding History





FY 2017 NSF Request by Account (\$M)

	FY 2016 Estimate	FY 2017 Discretionary		FY 2017 Mandatory	House Approp.	Sen. Approp
Research & Related Activities	\$ 6034	\$ 6079	0.8%	\$ 346	\$ 6079	\$ 6034
Education & Human Resources	880	899	2.1%	54	880	880
Major Res Equip & Facilities Const.	200	193	-3.6%		87	247
Agency Ops & Award Mgmt.	330	373	13%		340	330
National Science Board	4	4			4	4
Inspector General	15	15			15	15
Total NSF	\$ 7463	\$ 7564	1.3%	\$ 400	\$ 7405	7510



Two Different Budget Lines for Facilities

NSF FY 2017 Discretionary Request (\$ in millions)	FY 2017 Request
Research & Related Activities (R&RA)	\$ 6079
Education & Human Resources	899
Major Research Equipment & Facilities Construction (MREFC)	193
Agency Operations & Award Management	373
National Science Board	4
Office of Inspector General	15
Total NSF	\$ 7,564

NSF FY 2017 MREFC Request (\$ in millions)	FY 2017 Request
Regional Class Research Vessels (RCRV)	\$ 106.00
Large Synoptic Survey Telescope (LSST)	67.12
Daniel K. Inouye Solar Telescope (DKIST)	20.00



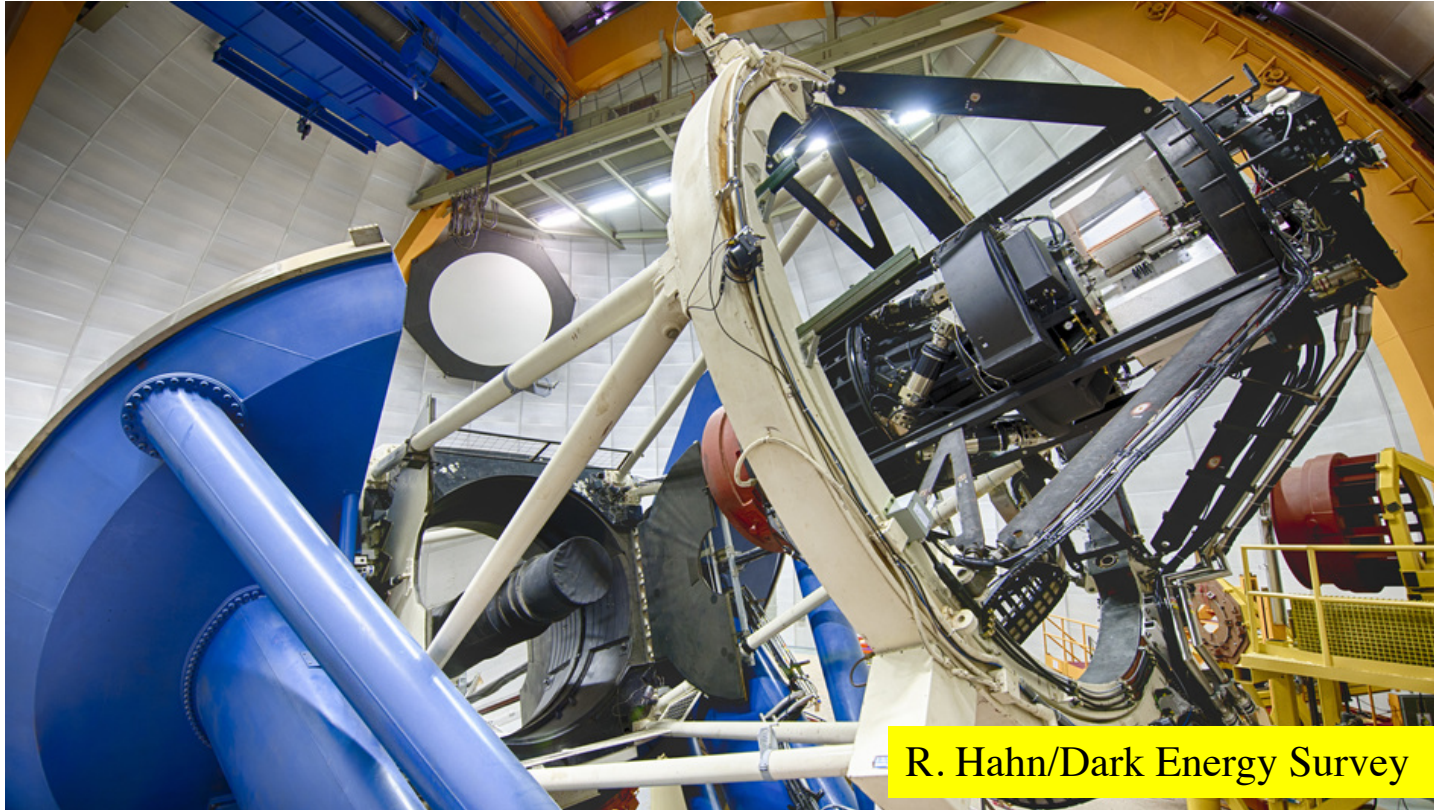
Impact of NSF Funding Method

- Major construction projects are funded from an NSF-wide budget line (MREFC), and do not have to be funded from the budget of an individual directorate or division. This makes it feasible to construct projects in the cost range of a half billion dollars or more.
- Operations funds for major facilities must come from the R&RA funds in a proposing directorate/division, which can take a significant fraction of a research division's budget.
- Assumptions about availability of operations funds must be made a decade before a facility comes into operation; overly optimistic assumptions can have serious consequences!



Some Science and Facility Highlights

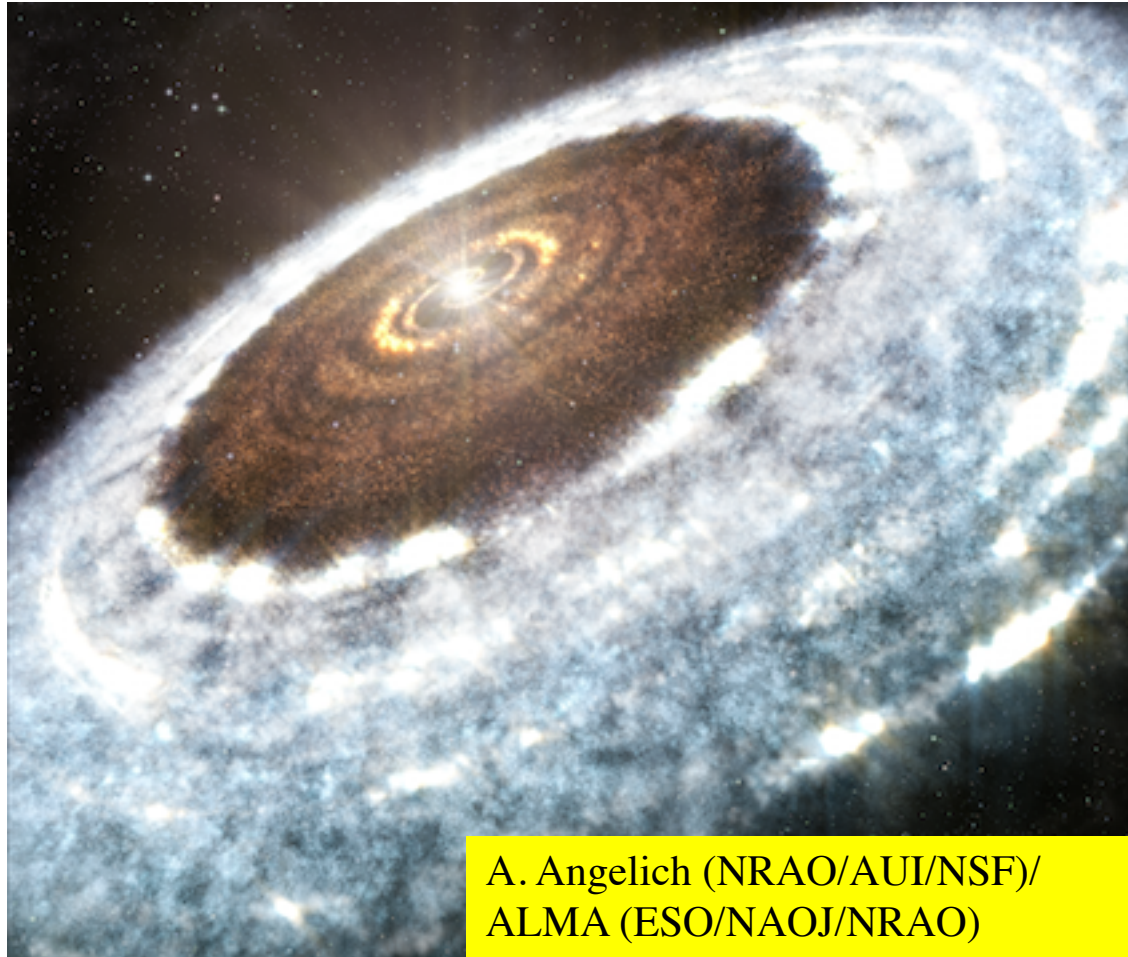
Blanco Telescope: Dark Energy Camera



- Dwarf planet 2014 UZ224 discovered in survey image (500 km diameter, at 90 AU from Sun) (Gerdes et al., U. Michigan)
- Comet P/2015 PD229 (Jupiter family of comets) (Cameron et al., U. Rochester)



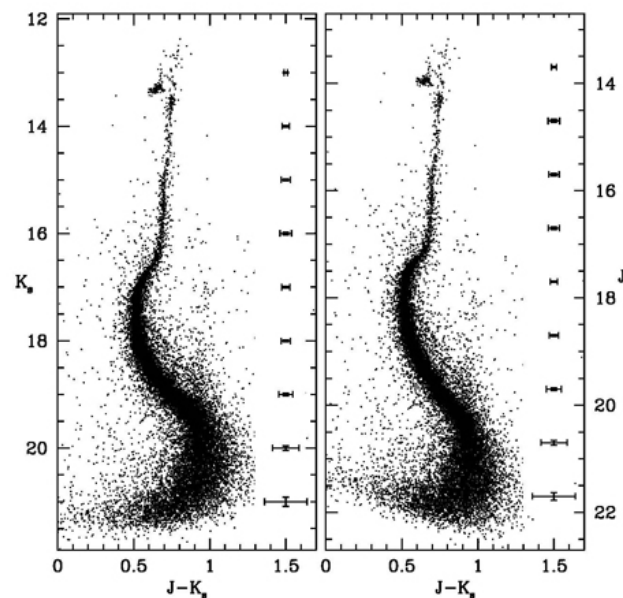
Snow Line in FU Orionis



- FU Ori imaged by ALMA in outburst, at 12 AU resolution
- Abrupt optical depth change at 42 AU attributed to condensation of water at the water-snow line. (Cieza et al., 2016, Nature 535, 258)

NGC 6624

- Bulge globular cluster NGC 6624 imaged in multiple near-IR colors with Gemini Multi-Conjugate Adaptive Optics (MCAO) system, giving 0.08-arcsec imaging over 93-arcsec field
- Detected main-sequence “knee,” found age of 12.0 ± 0.5 Gyr, and detected mass segregation, with increased fraction of low-mass stars with increasing distance from core
- Saracino et al. 2016 (arXiv:1609.02152)





NN-EXPLORE

Partnership for Exoplanet Discovery and Characterization



NN-EXPLORE is a joint NASA / NSF program for exoplanet science

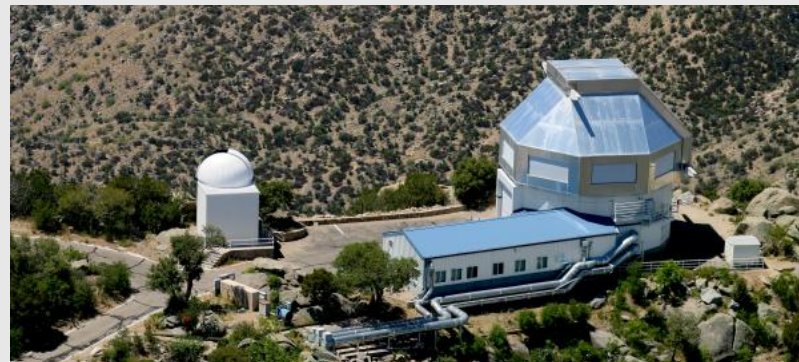
Stage 1: 2015 - 2018

- Exoplanet – targeted GO program with existing instrumentation using NOAO share (~50%) of WIYN 3.5m time
- NASA has solicited a facility-class Extreme Precision Doppler Spectrometer (EPDS) for the WIYN telescope. Commissioning in 2018/2019
- Instrument design selected: NEID (NN-Explore Investigations with Doppler Spectroscopy), S. Mahadevan, P.I. (Penn State University)



Stage 2: 2018 - TBD

- Exoplanet-targeted GO and guaranteed time program at WIYN with NEID
- Data management system to serve NEID data products (in coordination with NExSci)
- Community access to NEID instrument for observations that support NASA missions





Daniel K. Inouye Solar Telescope (DKIST)

- DKIST will be a 4.2-meter solar telescope, intended to study the Sun at the fundamental 20-km scale of the solar magnetic structures
- Under construction at Haleakala Observatory on Maui
- Completion scheduled for FY 2020.
- Top: Current view of DKIST enclosure atop Haleakala
- Bottom: Base ring of Telescope Mount Assembly under construction inside the DKIST enclosure

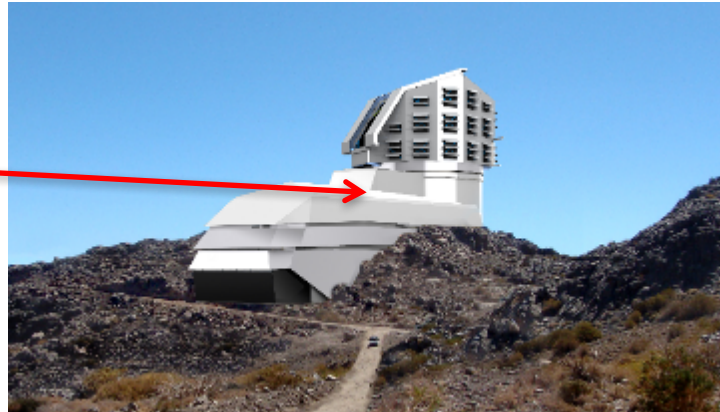
DKIST Construction Webcam 2016-09-26 09:09:37





Large Synoptic Survey Telescope

- Construction progressing, late 2022 start date for 10-yr survey.
- Updated study of NEO detection capabilities in progress.
- Kavli Futures Symposium Report—"Maximizing Science in the Era of LSST: A Community-Based Study of Needed US OIR Capabilities"
 - Sponsored by Kavli Foundation, in response to NSF request to LSST and NOAO



M1M3
(primary/tertiary)
actuator assembly
components



Electromagnetic Spectrum Management

- NSF works with other federal agencies through the National Telecommunications and Information Administration (NTIA) to protect the radio spectrum for scientific users
 - NSF spectrum management for NSF historically has been housed in AST
- Landscape is rapidly changing, and a diverse NSF research community now is making use of the spectrum in various ways
 - Passive and active remote sensing (e.g., radars)
 - Operational communication needs (e.g., Antarctic)
 - Smallsats and Unmanned Aerial Vehicles
 - Space-based Internet
- Internal NSF group (MPS, GEO, BIO, CISE, ENG) is developing recommendations regarding NSF spectrum management needs, development of a long-term strategy, organization and conflict-resolution within NSF, and representation in regulatory bodies



Other Interagency Activities of Note

- National Science and Technology Council (NSTC) Committee on Environment, Natural Resources, and Sustainability formed (2015) a subcommittee, SWORM, Space Weather Operations Research and Mitigation.
 - National Space Weather Strategy (NSWS) and Space Weather Action Plan (SWAP) released in 2015.
 - MPS/AST and GEO/AGS have been heavily involved, along with NASA heliophysics.
 - AST participates primarily via the research (DKIST) and research to operations (GONG) activities.
 - White House Executive Order released on October 13.
- NSTC Committee on Homeland and National Security has formed an interagency working group, DAMIEN, Detecting And Mitigating the Impact of Earth-bound Near Earth Objects.
 - DAMIEN is working on a strategy akin to the NSWS.
 - AST and NASA Planetary Sciences Division are participating.



Budget Outlook, Divestment, and Environmental Reviews



FY 2017 Budget Request--AST

\$M	FY15 Actual	FY16 Request	FY16 Estimate	FY17 Request Disc.
NSF Total	7344	7724	7464	7564
NSF R&RA	5934	6186	6034	6079
MPS	1337	1366	1349	1355
AST	245.2	246.5	246.7	247.7
MREFC	200.8	200.3	200.3	193.1



Decadal Survey and Portfolio Review

- AST relies on National Academy of Sciences decadal surveys in setting long-term priorities for ground-based astronomy program
 - *New Worlds, New Horizons in Astronomy and Astrophysics (NWNH)*, was released in 2010
 - *NWNH* assumed increase of 4%/yr in AST purchasing power
 - *NWNH* suggested carrying out a “senior review” if AST purchasing power was flat
- Portfolio Review Committee was commissioned as a broadly representative subcommittee of the MPSAC, to recommend program that could best address the science questions advanced by *NWNH*
 - Committee report was delivered in August 2012
 - Recommended a balance of small, medium, and large programs that would require divestment of numerous operating facilities from AST budget

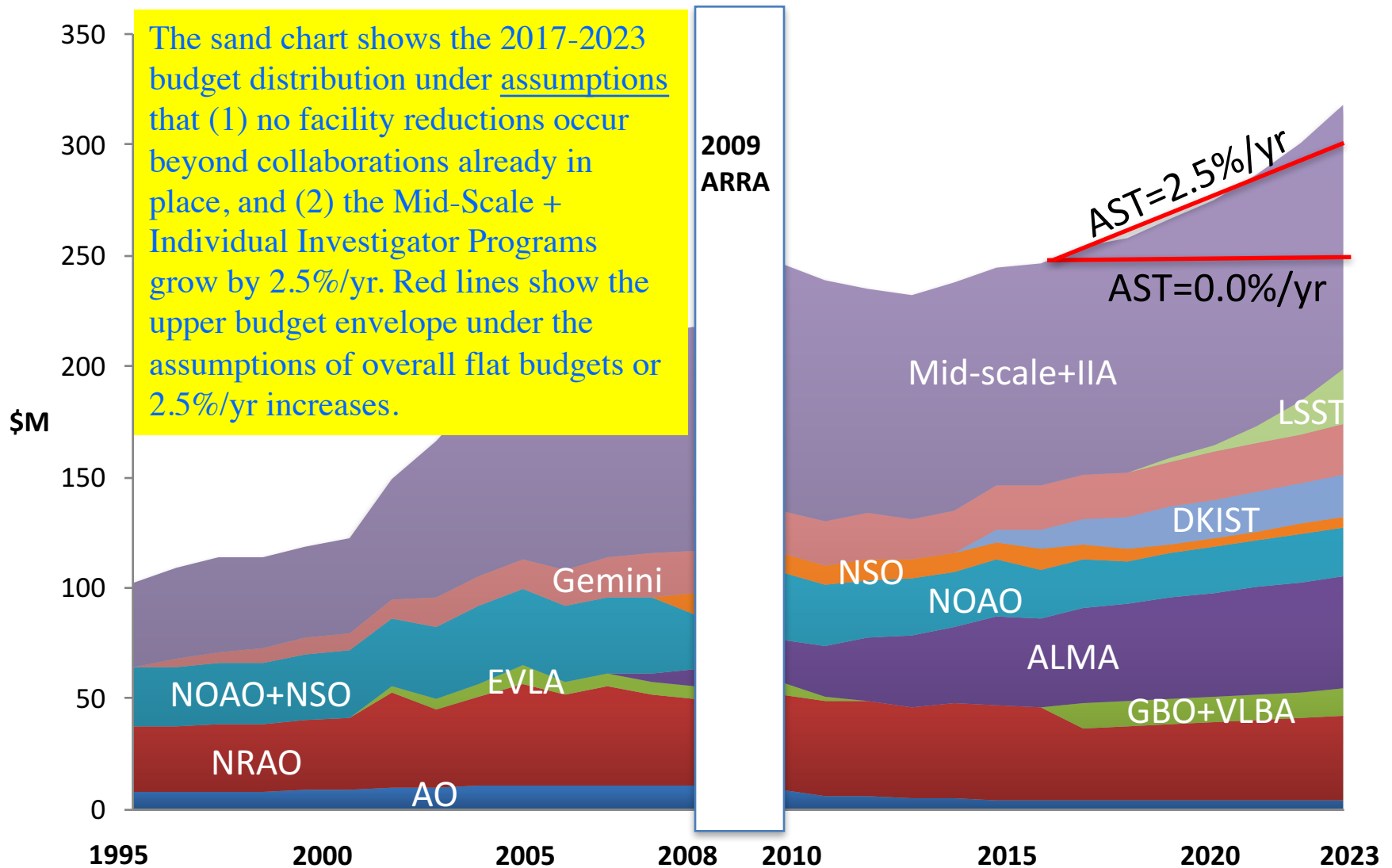


AST Portfolio Review

- Portfolio Review Committee was commissioned in 2011 as broadly representative subcommittee of MPS Advisory Committee
 - Responsive to *NWNH* recommendation for review of ongoing activities in a more constrained budget outlook
 - Charged to recommend program that best addressed *NWNH* science questions within budget scenarios well below *NWNH* assumption (doubling in 10 years)
- Portfolio Review Committee reported out in August 2012
 - Recommended a balance of small, medium and large programs that would require divestment of a number of operating telescopes from AST budget
 - Recommended divestments amounted to \$45 million in annual AST savings
- Status of NSF responses is being reported regularly
 - Dear Colleague Letters, NSF 14-022 (Dec. 2013) and NSF 15-044 (March 2015)
 - Regular (annual or more often) reporting to Astronomy and Astrophysics Advisory Committee, American Astronomical Society town halls, several National Research Council committees, and Congressional staff



Hypothetical Budget Runouts for AST





Facility Futures

(as of October 27, 2016)

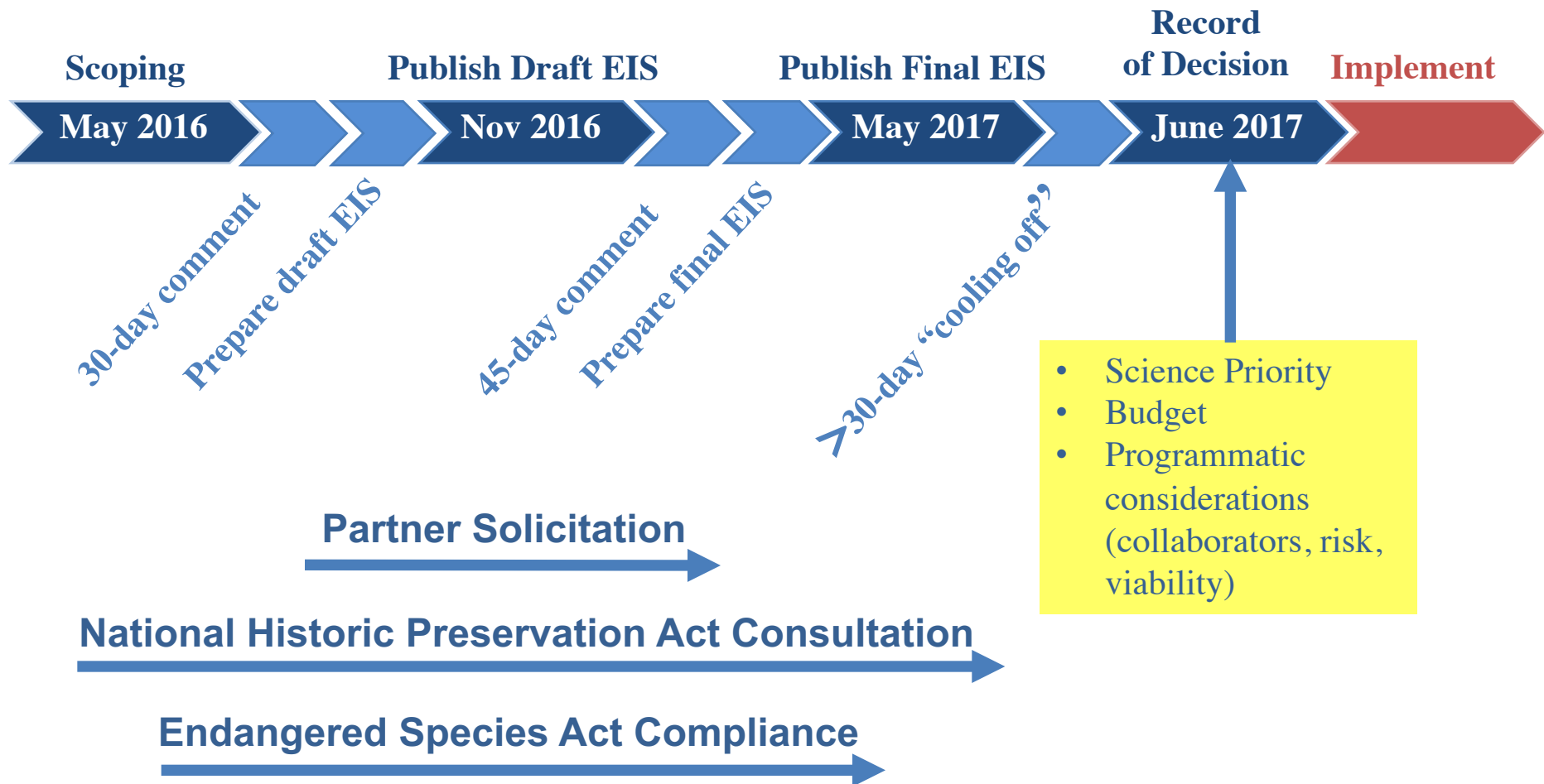
Telescope	Status
KPNO 2.1m	Caltech-led consortium (Robo-AO) operating for FY 2016-2018
Mayall 4m	Slated for DESI; bridge from NSF to DOE; NSF/DOE MOU for transition
WIYN 3.5m	NOAO share to NASA-NSF Exoplanet Observational Research Program; NSF/NASA MOU in place; NASA instrument selected
GBO	Separation from NRAO in FY 2017; ~25% partnership in place; started Environmental Impact Statement (EIS) process last week
LBO/VLBA	Separation from NRAO in FY 2017; MOA with US Navy in place at 50%
McMath-Pierce	No obvious partner opportunities; very small user community
GONG/SOLIS	SOLIS is off Kitt Peak; GONG refurbishment; Interagency Agreement with NOAA signed (NOAA sharing GONG operations costs)
Sacramento Pk.	University consortium in development, and NSF funded NMSU for transition to consortium; started EIS process; completion in 2017
Arecibo	Formal environmental review in process; completion of EIS process and issuance of Record of Decision targeted for 2017
SOAR	Post-2020 status to be reviewed



Environmental Reviews-Targeted Timeline

- May 2016: Initiated Environmental Impact Statement (EIS) process and consultation under National Historic Preservation Act (NHPA) Section 106 for Arecibo.
- July 2016: Began EIS and NHPA process for Sacramento Peak Observatory.
- October 2016: Began EIS and NHPA process for Green Bank Observatory.
- FY 2017: Consider EIS and NHPA process for Long Baseline Observatory (formerly VLBA) and McMath-Pierce Solar Telescope.
- June 2017-Early 2018: Conclude formal environmental reviews and consideration of alternatives. Select preferred alternatives in Record of Decision, which incorporates environmental reviews and many other considerations. Begin implementation.
- No decisions have been made, or will be made until issuing a Record Of Decision for a facility or telescope under formal consideration.

Target Dates for Arecibo Environmental Impact Statement (EIS)



Sac Peak and Green Bank are on similar paths, 2-6 months behind Arecibo



Recent Community Reports



New Worlds, New Horizons: A Midterm Assessment

- Recommendation 3-1: “National Science Foundation (NSF) should proceed with divestment from ground-based facilities which have a lower scientific impact, implementing the recommendations of the NSF [AST] Portfolio Review, that is essential to sustaining the scientific vitality of the U.S. ground-based astronomy program as new facilities come into operation.”
- Recommendation 3-2: “The NSF and the National Science Board should consider actions that would preserve the ability of the astronomical community to fully exploit the Foundation’s capital investments in ALMA, DKIST, LSST, and other facilities. Without such action, the community will be unable to do so because at current budget levels the anticipated facilities operations costs are not consistent with the program balance that ensures scientific productivity.”
- Similar recommendations from AAAC; see later presentation.



Elmegreen OIR Report

- April 2015: National Academies delivered report on “Optimizing the U.S. Ground-Based Optical and Infrared Astronomy System” (aka Elmegreen report).
 - Report made recommendations about some priorities, but did not provide details of instrumental recommendations.
 - AST wrote to NOAO and LSST Directors, requesting more detailed assessment of instrumental requirements (see following slides).
- Several recommendations relating to NOAO fostering of community, which go well beyond base scope funded by NOAO; under discussion/development with NOAO.
- Overall NSF response published in Dear Colleague Letter NSF 15-115.



LSST/NOAO Symposium Report

- August 2015: NSF wrote to the AURA President and the LSST and NOAO Directors requesting consideration and prioritization of specific technical capabilities for the US Optical/Infrared Telescope System that are required to fully realize LSST-enabled science.
 - Community working groups set up to consider six representative science cases for LSST.
 - Culminated in May 2016 workshop sponsored by Kavli Foundation.
- October 2016: Report of the Kavli Futures Symposium “Maximizing Science in the Era of LSST: A Community-Based Study of Needed US OIR Capabilities”



Kavli Symposium Recommendations-Summary

- Six LSST science cases ranged from Small Bodies in the Solar System to Cosmic Structure and Cosmology.
- For each science topic, capabilities were classified as Critical, Very Important, or Important.
- Critical capabilities for more than one science case
 - Optical wide-field imager on 3-10m telescope.
 - Multi-Object Spectrograph ($R=5000$, 0.35-1.3 micron) on 3-30m telescope.
 - OIR single-object spectrograph ($R=1000-5000$, 0.35-2.5 micron).
 - OIR multi-object spectrograph ($R>20,000$) on 8-30m telescope.
- Estimated required time for specific LSST science cases, and also noted existing (or in development) instruments that could fulfill the needs, as well as holes in availability for the general U.S. community.



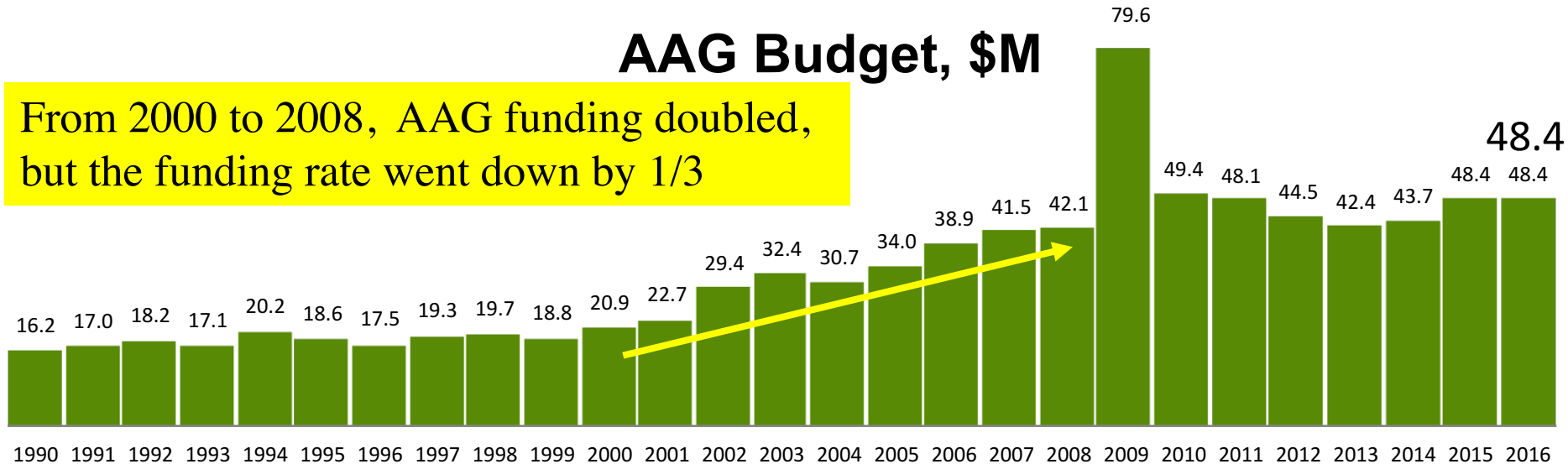
Individual Investigator Programs



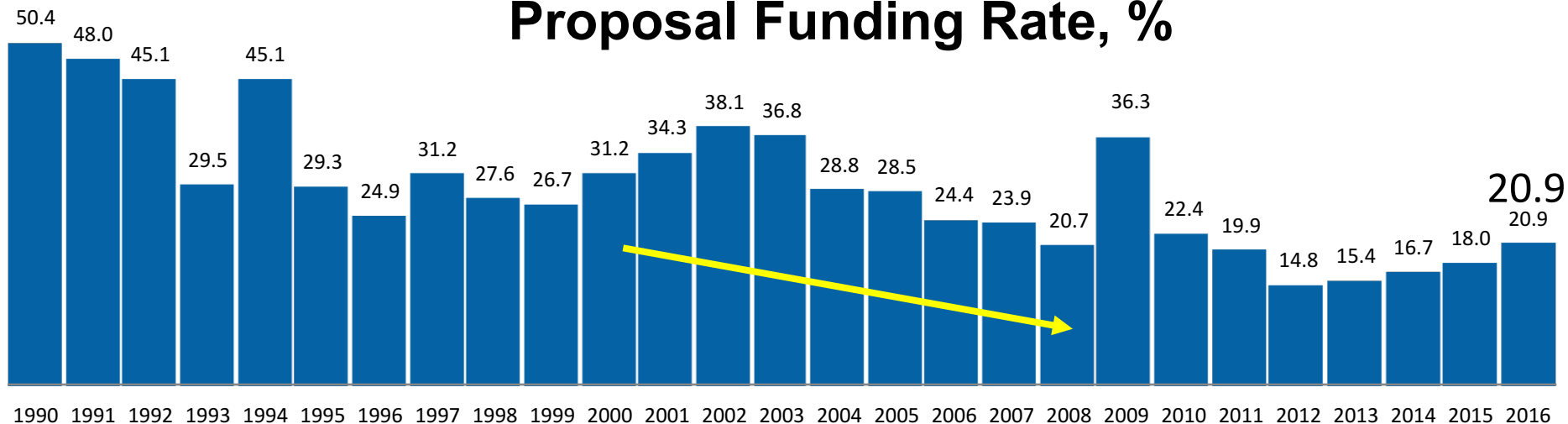
AAG Funding History, 1990-2016

AAG Budget, \$M

From 2000 to 2008, AAG funding doubled, but the funding rate went down by 1/3



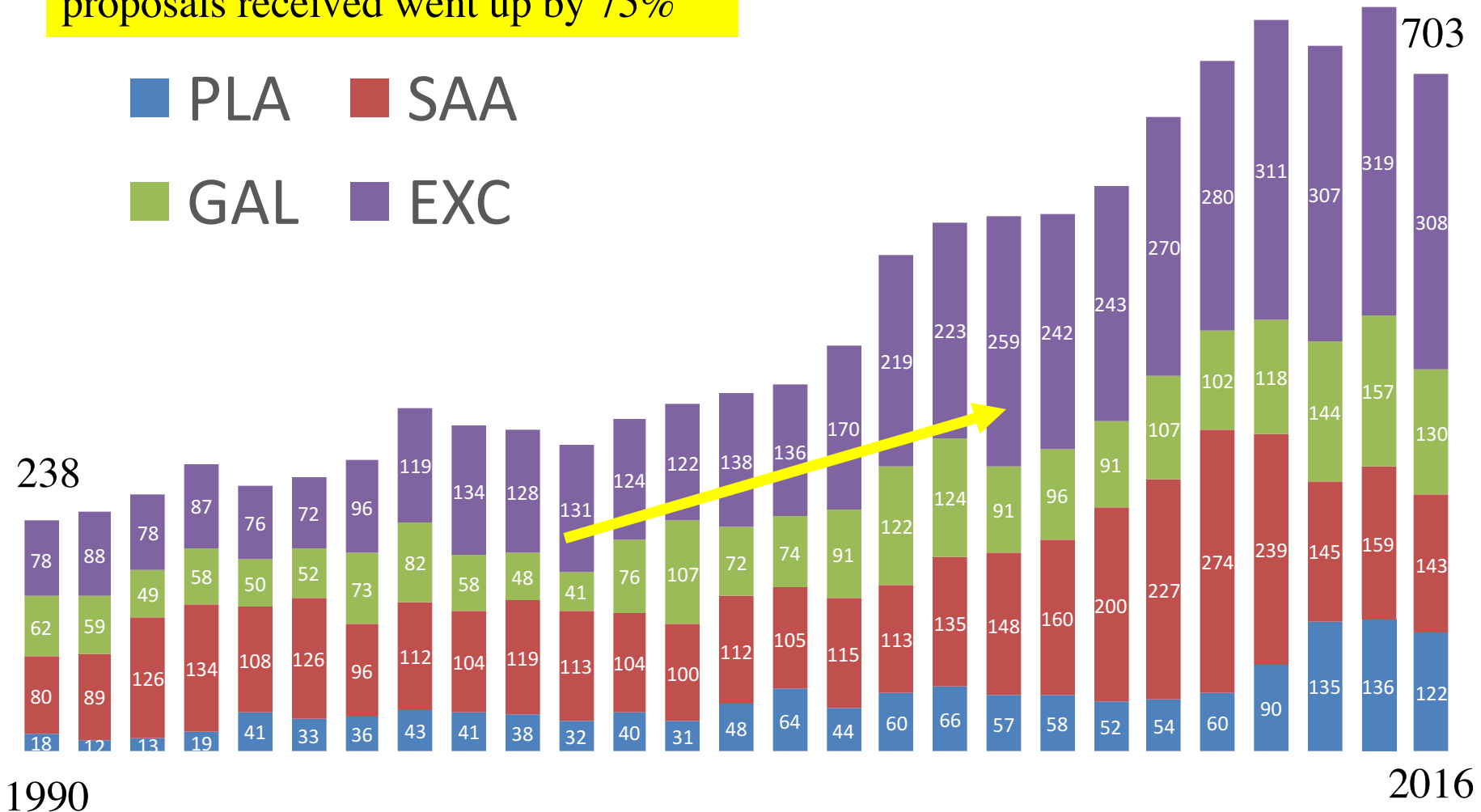
Proposal Funding Rate, %





Proposals in AAG, 1990-2016

From 2000 to 2008, the number of proposals received went up by 75%





Changes in AST AAG Program for FY 2017

- For FY 2017, AST will run a pilot program with NO PROPOSAL DEADLINE for the Planetary/Exoplanetary and Solar portions of the Astronomy and Astrophysics Research Grants (AAG) program.
 - Purposes: Understand and resolve issues with proposal handling and merit review; alleviate impact of life events for proposers; investigate impact on proposal load over the year; enable proposal file updates for minor errors.
 - Solicitation NSF 16-602: Solar and Planetary Research Grants (SPG).
 - Declined proposals may not be resubmitted for 12 months.
- The rest of AAG will run as before, with a November 15, 2016 proposal deadline (Solicitation 16-574).
- Budget breakdowns between AAG and SPG will remain similar to FY 2016.



MSIP Round 2 Awards, FY 2016-2017

Awarded Proposal	PI	Total NSF Funds	Yr Funded
Zwicky Transient Facility	Kulkarni	\$9.0M	FY 2014
Advanced ACTPol	Staggs	\$10.0M	FY 2014
H Epoch of Reionization Array	Parsons	\$2.1M	FY 2014
Event Horizon Telescope	Doeleman	\$6.5M	FY 2015
POLARBEAR	Lee	\$5.0M	FY 2015
NANOGrav Phys Frontier Ctr	Siemens	\$14.5M (AST 20%)	FY 2015
CARMA closeout	Carlstrom	\$2.0M	FY 2014
CLASS-CMB, Large Ang. Scale	Bennett	\$4.4M	FY 2016
TolTEC, mm camera on LMT	Wilson	\$6.1M	FY 2016/17
HERA	Parsons	\$9.5M	FY 2016/17
SuMIRE (Subaru galaxy surv.)	Strauss	\$5.5M	FY 2016
CHARA (open access)	ten Brummelaar	\$3.9M	FY 2016
Las Cumbres (open access)	Boroson	\$3.0M	FY 2016/17



ACT



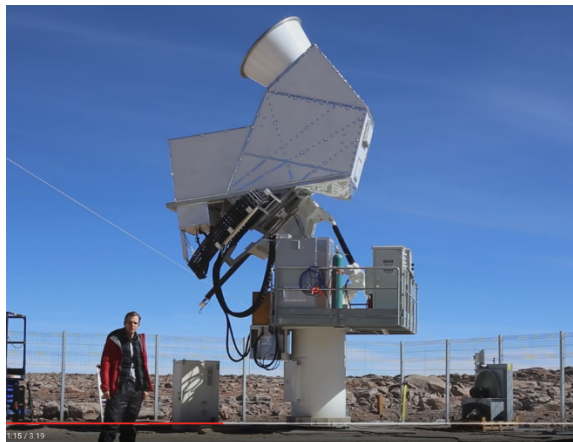
ACT + Polarbear



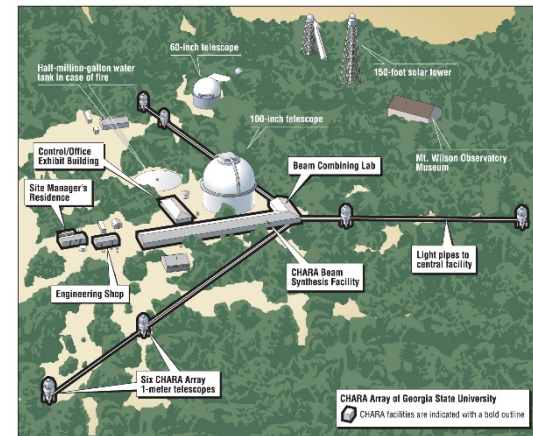
Polarbear



ZTF



CLASS



CHARA



HERA



ToITEC/
LMT

AAAC-NSF/AST

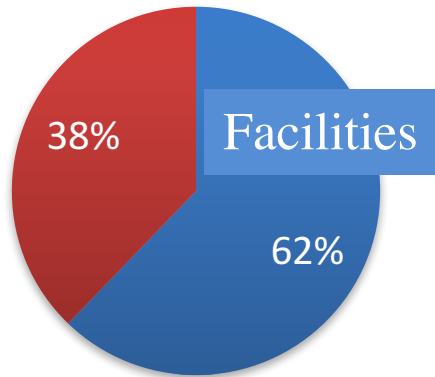


Backups/extras

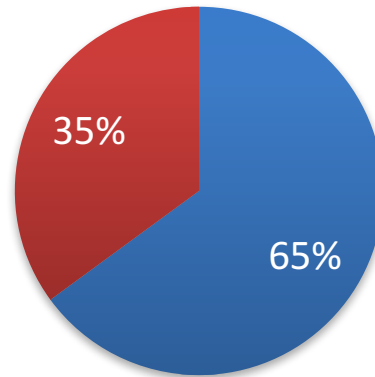


Historical Funding Breakdown

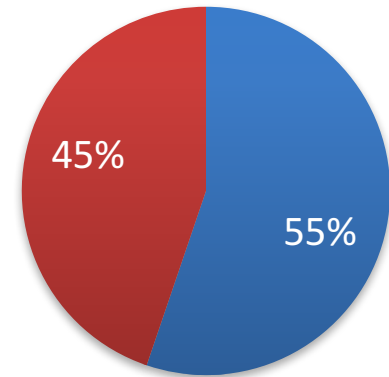
1995



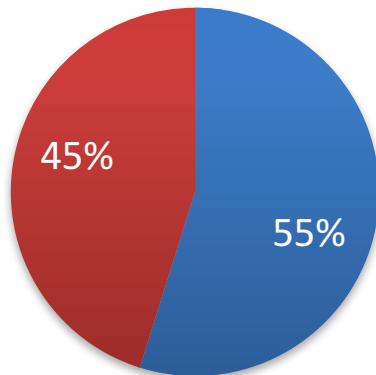
2000



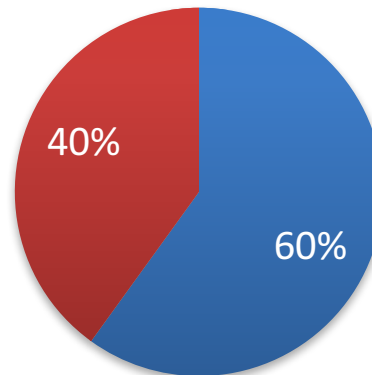
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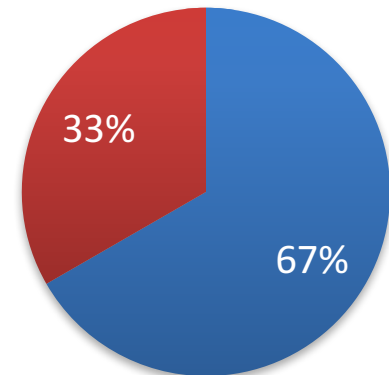
2010



2015



2020?





FY 2017 AST Disc. Request: \$247.7 M

Program	\$M	Program	\$M
ALMA	43.25	AAG+SPG (grants)	43.38
NRAO	32.00	MSIP (Mid-scale)	18.00
NOAO	21.83	ATI (Adv. Tech.)	8.00
Gemini	20.42	CAREER	4.90
DKIST	14.00	AAPF (Postdoc)	2.40
GBO+VLBA	11.50	REU (Undergrad)	2.00
NSO (sans DKIST)	6.00	PAARE (Diversity)	1.50
Arecibo	4.20	Misc+expenses*	12.35
DKIST mitigation	2.00		

*Misc+expenses includes Panels, IPAs, GSMT, DESDM, KITP, SPT, Spectrum, Education/Special Programs, Aspen Center, NSF ops, grants reserve, etc.



Community Recommendations to NSF

- August 2012: AST Portfolio Review (recommended by decadal survey) recommended a number of facilities for divestment, and others for future consideration, depending on budget and other factors.
- March 2016: Astronomy and Astrophysics Advisory Committee Recommendation: “Strong efforts by NSF for facility divestment should continue as fast as is practical.”
- April 2016: GEO/AGS Portfolio Review (Recommendation 9.11): Recommendation to reduce GEO/AGS contribution to Arecibo operations from \$4.1 million/yr to \$1.1 million/yr by 2020. (MPS/AST also spent \$4.1 million in FY 2016)
- August 2016: National Academies mid-term decadal assessment (Recommendation 3-1): “National Science Foundation (NSF) should proceed with divestment from ground-based facilities which have a lower scientific impact, implementing the recommendations of the NSF [AST] Portfolio Review, that is essential to sustaining the scientific vitality of the U.S. ground-based astronomy program as new facilities come into operation.”



Acronym Dictionary

- AAG=Astron. & Astrophys. Research Grants
- ALMA=Atacama Large Mm/submm Array
- AR=Arecibo
- AST=NSF Division of Astronomical Sciences
- DAMIEN=Detecting And Mitigating the Impact of Earth-bound Near Earth Object
- DESI=Dark Energy Spectroscopic Instrument
- DKIST=Daniel K. Inouye Solar Telescope
- DoD=Department of Defense
- DOE=Department of Energy
- EIS=Environmental Impact Statement
- EVLA=Expanded Very Large Array
- GBO=Green Bank Observatory
- GONG=Global Oscillations Network Group
- GPI=Gemini Planet Imager
- IPA=Intergovernmental Personnel Act
- LBO=Long Baseline Observatory
- LIGO=Laser Interferometer Gravitational-wave Observatory
- LSST=Large Synoptic Survey Telescope
- MPS=NSF Directorate for Mathematical and Physical Sciences
- MREFC=Major Research Equipment & Facility Construction
- MSIP=Mid-Scale Innovations Program
- NASA=National Aeronautics and Space Administration
- NN-EXPLORE=NASA-NSF Exoplanet Observational Research partnership
- NOAA=Natl Oceanic and Atmos. Admin.
- NOAO=National Optical Astronomy Observatory
- NRAO=National Radio Astronomy Observatory
- NRC=National Research Council
- NSO=National Solar Observatory
- NWNH=New Worlds, New Horizons
- OIR=Optical/Infrared
- OMB=Office of Management and Budget
- PHY=NSF Division of Physics
- R&RA=Research and Related Activities
- SOAR=Southern Astrophysical Research Telescope
- SOLIS=Synoptic Optical Long-term Investigations of the Sun
- SPG=Solar and Planetary Research Grants